Biophysical Overview of Gilbert Bay: A Proposed Marine Protected Area in Labrador

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by

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Abstract

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Gilbert Bay is located along the southern coast of Labrador (52° 35′N 56° 00′W) near the communities of Williams Harbour and Port Hope Simpson. It was designated as an Area of Interest (AOI) in the Marine Protected Areas (MPA) Program by the Department of Fisheries and Oceans (DFO), on October 12, 2000. This was the first site in the Newfoundland Region to receive AOI status. The area consists primarily of exposed shield rock. Its climate is influenced by the cold Labrador current flowing southward from the arctic. The plankton community consists of subarctic species due to influence of the Labrador current. Gilbert Bay is restricted from the Labrador Sea by a narrow entrance, and the benthic environment reflects that of a sheltered bay. A number of fish species are reported to occur in Gilbert Bay, including a resident population of Atlantic cod. The resident Atlantic cod population was influential in the designation of this area as a potential MPA. Human activities in Gilbert Bay consisted primarily of commercial fishing for Iceland scallop, cod and a variety of recreational fisheries. Several information gaps exist that limit the completeness of a biophysical overview, which serve to guide future research.

Résumé

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La baie Gilbert se trouve sur la côte Sud du Labrador (52 ° 35'N – 56 ° 00'W), près des communautés de Williams Harbour et de Port Hope Simpson. Elle a été désignée le 12 octobre 2000 comme site d'intérêt dans le cadre du Programme des zones de protection marine (ZPM) par le ministère des Pêches et des Océans (MPO). C'était le premier site de la Région de Terre-Neuve à recevoir ce statut. La zone se compose avant tout de roche exposée du Bouclier canadien. Son climat est influencé par le courant froid du Labrador qui descend de l'Arctique. La communauté planctonique se compose d'espèces subarctiques à cause de l'influence du courant du Labrador. La baie Gilbert est protégée de la mer du Labrador par un étroit passage, et le milieu benthique correspond à celui d'une baie abritée. On signale dans la baie un certain nombre d'espèces de poissons, dont une population résidente de morue franche. C'est la présence de cette population qui a joué dans la désignation de la baie comme ZPM potentielle. Les activités humaines dans la baie Gilbert sont essentiellement la pêche commerciale du pétoncle d'Islande et de la morue, et diverses pêches sportives. De nombreuses lacunes dans les connaissances limitent la validité de la description physique et vont orienter les recherches futures.

INTRODUCTION

On October 12, 2000, the Department of Fisheries and Oceans (DFO) under authority of the *Oceans Act* publicly announced Gilbert Bay, Labrador, as an Area of Interest (AOI) in the regional Marine Protected Areas (MPA) Program. The announcement of Gilbert Bay as an AOI or MPA candidate site was the first step toward MPA status. Following AOI designation sites may require additional site specific information in order for DFO and other stakeholders to assess its suitability as a MPA. During this investigative phase, DFO will examine information describing ecological, social, and technical aspects of the AOI, to ensure that requirements of the *Oceans Act* are met. This biophysical overview forms part of the ecological assessment. We have described physical ecosystem components such as climate, geology, and oceanography, as well as, biological components such as primary production, benthic habitats, including flora and fauna associated with Gilbert Bay and the surrounding area.

Harper *et al.* (1983, 1993) developed hierarchical criteria to delineate marine regions that are primarily biophysical in nature. Their classification parallels terrestrial ecosystem classification and is hierarchical in approach. The smallest scale hierarchy is the ecosection. A marine ecosection is characterized by unique physiographic, oceanographic and biological assemblages that are related to water depth and habitat. This biophysical overview concentrates on a relatively small area consistent with an ecosection (Harper 1983).

This overview adopts a comparable approach to Singh *et al.* (2000), to describe components of the Gilbert Bay ecosystem. Their initial ecological overview of the Musquash Estuary AOI in New Brunswick summarized current literature and various studies initiated and planned for the Musquash Estuary. It identified several important subsets of information to comprise an effective ecological overview.

The available literature and various unpublished information pertaining to Gilbert Bay is presented. Information gaps that may warrant future investigation have been identified. This report will be useful to decision makers, such as various community groups, aboriginal groups, interested individuals, other stakeholders, and DFO to assist in development of a management plan for the Gilbert Bay AOI.

BACKGROUND

The cod fishery was once the mainstay of people along the southern coast of Labrador, and people continue to have a strong connection with cod. Overfishing significantly reduced the northern cod stock and lead to a fishing moratorium from 1992-1998. The northern cod stock has not shown signs of recovery since the northern cod moratorium began in 1992 (Lilly et al. 2000). Atlantic cod is currently listed by COSEWIC (Committee on the Status of Endangered Wildlife in Canada) as a species having special concern status. The existence of a resident Atlantic cod population in Gilbert Bay and the extremely low abundance of cod in surrounding bays and offshore

areas is the primary reason why Gilbert Bay was recognized by local communities as an AOI.

Communities in the vicinity of Gilbert Bay, namely Port Hope Simpson (population ~589) and William's Harbour (population ~60) submitted a proposal to DFO in 1999 promoting Gilbert Bay as a potential MPA under the *Oceans Act*. The proposal outlined the concern that cod fishing in Gilbert Bay could irreversibly deplete a unique cod population residing there. Concerns expressed in the proposal were based on local knowledge of Gilbert Bay cod and research conducted by Memorial University of Newfoundland (MUN), describing their unique characteristics.

Atlantic cod occur in continental shelf waters throughout the North Atlantic. Cod inhabiting the northwest Atlantic continental shelf are divided into stocks, based on biological characteristics, for management purposes. The northern cod stock consists of NAFO divisions 2J+3KL (Fig.1). The majority of inshore northern cod are found in several bays along the northeast coast of Newfoundland (DFO 2001). Inshore cod are commonly called 'bay cod', whereas cod that spawn offshore, either migratory or non-migratory, are referred to as offshore cod in this report. Gilbert Bay cod represent the only known isolated population of inshore cod along the Labrador coast. The unique population of cod found in Gilbert Bay, hereinafter is referred to as Gilbert Bay cod or bay cod.

The majority of research conducted in Gilbert Bay has focused on Atlantic cod residing in the bay. In 1996, Wroblewski *et al.* (1998) conducted a cod grow-out experiment in Gilbert Bay which demonstrated that the growth rate of Gilbert Bay cod could be significantly increased, and that cod aquaculture was possible on the Labrador coast. They achieved this result by holding wild Gilbert Bay cod in sea cages near the surface in warm water and feeding them a natural diet of herring and capelin. Other studies show that Gilbert Bay cod are isolated (Green and Wroblewski 2000) and genetically distinct from other populations of the species (Ruzzante *et al.* 2000; Beacham *et al.* 1999). Their natural growth rate, and timing and location of spawning also differs from northern cod and other Atlantic cod populations (Morris 2000).

Historically, a single family enterprise fished commercially in Gilbert Bay from the late 1970's until the northern cod fishing moratorium began in 1992. As the numbers of offshore fish were declining in years immediately preceding the moratorium, fishing pressure in Gilbert Bay increased. This occurred as a result of additional fish harvesters from Williams Harbour and Port Hope Simpson increasing their fishing efforts within the bay (Wroblewski 1998) as fish disappeared from traditional fishing areas. The fishing moratorium on northern cod (NAFO Divisions 2J3KL) was lifted in 1998, and limited fishing has occurred since then. Preliminary evidence suggests that at least partial recovery of the Gilbert Bay cod population occurred during the moratorium (Morris 2000: Morris and Green submitted).

When the northern cod fishery resumed in 1998, fish harvesters in the vicinity of Gilbert Bay became aware of the absence of cod on traditional fishing grounds and

relative abundance of Atlantic cod in Gilbert Bay. Subsequently there was a substantial amount of fishing effort within the bay at this time. During the 1998 commercial index fishery, approximately 14 fishing boats were observed fishing Atlantic cod in Gilbert Bay (George Rowe, Field Technician, P. O. Box 12, Port Hope Simpson, Labrador, AOK 4EO, Pers. Comm.). In addition, commercial fishing in this area has also targeted Gilbert Bay cod, whereas historically, effort included both these cod and migratory offshore cod. Since 1998 local people have expressed concern over the status of Atlantic cod in Gilbert Bay (Morris *et al.* 2002). DFO restricted commercial and recreational Atlantic cod fishing from 70% of Gilbert Bay after 1998. There is still not enough information to estimate the abundance of Gilbert Bay cod.

AREA MORPHOLOGY

Gilbert Bay is a long narrow inlet located on the southeast coast of Labrador, 52°35'N 56°00'W; Gilbert Bay comprises 60 km^2, is 20 km long and less than 80 m deep. It has three narrow entrances (≤500 m) that restrict it from neighboring Alexis Bay and the Labrador Sea (Fig. 1). These are located at Winnard Tickle, Williams Harbour Run, and Main Tickle (Fig. 2). The main arm of Gilbert Bay and several of its restricted arms (Snooks Arm, Long Arm, and The Shinneys), generally run parallel in a northwest-southeast direction. This configuration is due to retreat of the Wisconsin ice sheet. Glacier retreat eroded an extensive system of fjords along the Labrador coast and stripped the land of surficial sediments (Anon. 1997). Deglaciation of the southern Labrador coast occurred 11,000 to 14,000 years before present (Clark and Fitzhugh 1992). Today the area consists predominately of exposed Precambrian Shield rock (Anon. 1980). Like much of the Labrador coast, the Gilbert Bay shoreline consists of exposed bedrock and rocky beaches, while smaller sediments are generally found near estuaries (Anon. 1997).

Two rivers flow into Gilbert Bay. Gilbert River is located at the head of Gilbert Bay and Shinneys River is located in the inner part of The Shinneys (Fig. 2). Gilbert River is 132 km long and drains a watershed of 642 km^2 (Anderson 1985). Shinneys River is 76 km long and has a drainage area of 313 km^2 (Anderson 1985). During spring, the fresh water contribution of these rivers to Gilbert Bay is greatly increased due to melting ice and snow within these watersheds. Prior to the construction of the Trans-Labrador Highway in 2001, these river systems were inaccessible by road. Currently there are no communities or forestry operations within either of these watersheds. Both rivers are minimally exploited by recreational fishing, compared to other more accessible rivers. Accessibility provided by the Trans-Labrador Highway may increase human impacts within these watersheds in the future.

CLIMATE

The Labrador coast falls within a narrow subarctic zone separating polar from temperate regions (Stonehouse 1989). The cold Labrador Current brings subarctic conditions southward along the Labrador coast influencing the coastal areas. Therefore,

latitude is not a suitable means to describe the climate of the Labrador coast. Average air temperatures for the period 1984 until 1997, recorded at Mary's Harbour (located 35 km south of Gilbert Bay), Labrador are; February –14°C, April –2°C, July 13°C, and October 4°C. These temperatures are similar (±1°C) to those reported by Banfield (1993) for the Cartwright area, 80 km north of Gilbert Bay.

The Labrador Current flows southward along the coast, formed by a convergence of Arctic water from the Baffin Island Current and a westward flowing branch of the West Greenland Current. These water masses converge in Hudson Strait (Smith 1937; Lazier 1982; Tang *et al.* 1996). The Baffin Island Current makes up 20% of, and forms the inshore part of the Labrador Current (Lazier 1982). This water is characterized by lower temperatures (-1°C to +2°C) and salinity (32.5-33.5 ppt) than the offshore portion, which consists of water originating from the West Greenland Current (Tang *et al.* 1996). Surface water temperatures in some Labrador bays, including Gilbert Bay, experience higher water temperatures than the Labrador Current in summer due to local warming. Some Labrador inlets may reach temperatures similar to those along the south coast of Newfoundland (Steele 1975).

HYDROGRAPHY

Gilbert Bay is ice covered approximately six months of the year. Freeze up usually occurs during November - December; ice usually melts again by early May. During winter, ice thickness may exceed one meter at locations where tidal flows are minimal. Surface water temperatures increase rapidly soon after ice has left the bay, usually in mid May (Morris 2000). In spring a large volume of fresh water flows into Gilbert Bay due to melting ice and snow. The water column in Gilbert Bay becomes stratified due to temperature and salinity gradients. A steep water density gradient was observed to a depth of 5 m in May and June 2000 (Fig. 3; Morris 2000). After spring runoff, fresh water influence is reduced, and a density gradient is maintained by differences in water temperature. The annual temperature fluctuation of surface water in Gilbert Bay ranges from –1.8°C during winter to 15°C during summer (Fig. 4). At depths greater than 50 m, water temperatures remain subzero throughout the year (Fig. 5, Green and Wroblewski 2000). The mean tidal range at Denbigh Island (Fig. 2) is 1 m and the largest spring tide is 1.52 m (DFO 2001).

Portions of Gilbert Bay are separated by a number of shallow sills rising to depths of approximately 5 m. Sills may restrict the exchange of deep water (Picard and Emery 1982). When the depth of a sill is shallow enough to penetrate into a low-salinity out-flowing upper layer, full estuarine circulation cannot develop and subsurface inflow of saline water does not occur (Picard and Emery 1982). During the spring run-off in Gilbert Bay, the low salinity surface layer appears to reach sill depth at the entrance to The Shinneys, which may affect circulation of water at greater depths than the sill

(Fig. 3 and 5). Therefore, morphology of Gilbert Bay may affect water transport at various depths.

The stratification of Gilbert Bay and its morphology may have significant biological consequences. Ogac Lake, the small landlocked head of a fjord in Frobisher Bay, contains an isolated Atlantic cod population (Fisheries Research Board of Canada, 1952, p. 109-110; Mclaren 1967). Like Gilbert Bay, Ogac Lake has a river flowing into the head of the lake reducing surface salinities to less than 20 ppt to a depth of 5 m. It is approximately 1.48 km^2, has a maximum depth of 60 m, and the entrance is approximately 30 meters wide (Mclaren 1967). The entrance is 1m bellow maximum tides in spring (maximal range 12 m) and it receives salt water only during these highest tides (Mclaren 1967). This morphology has important hydrological and biological consequences (Mclaren 1967), such as maintaining its isolated cod population. Gilbert Bay may also experience conditions that retain cod eggs and larvae as a result of its hydrographic and morphometric features. Sinclair (1988) suggests that the very existence of a population depends on the ability of the larvae to remain aggregated during the first few months of life. The morphometric and hydrographic features of Gilbert Bay may retain eggs and larvae and enable a local population to exist.

Water colouration in The Shinneys is usually dark brown, particularly during the spring thaw, due to the presence of tannins from the Shinneys River and Gilbert River. Visibility during spring may be restricted to a shallow depth (<2 m). Surface water becomes less dark as river waters recede, and visibility improves.

PLANKTON AND FISH LARVAE

The zooplankton community of the Labrador coast and shelf are typically subarctic (Dunbar 1954) in that it consists of a mixture of Arctic and Atlantic species. Near-shore zooplankton consists more of Arctic than Atlantic species. This is evident by low abundance of common Atlantic water species *Calanus finmarchicus*, near-shore. Bays along the Labrador coast support a higher zooplankton biomass and ichthyoplankton biomass in the upper 100 m than offshore locations (Buchanon and Foy 1980). During the summer of 1979, 117 species of zooplankton were identified in the Labrador Current (Buchanon and Foy 1980). Dominant species consisted of *Pseudocalanus minutus, C. finmarchicus, C. glacialis* and *C. hyperboreus* (Huntly *et al.* 1983). The presence of *C. glacialis,* suggests the presence of the arctic water component of the Labrador current. Other groups comprising more than 1% of the abundance or biomass include barnacles, larvaceans, cnidarians, pteropods, amphipods and chaetognaths (Buchanon and Foy 1980).

The dominant phytoplankton in the Labrador Sea is diatoms, microflagellates, and chrysophytes. Phytoplankton species most common in the near shore portion of the Labrador Current are mainly centric, chain-forming diatoms. The most common genera are *Chaetoceros*, a typical bloom species. The second most common genera are *Thalassilosira*. Crustaceans are reported as the most diverse and numerically abundant

group of zooplankton in Labrador waters. The near-shore portion of the Labrador Current is likely to have similar plankton species composition. A spring bloom begins in May, and reaches a maximum in June, in the upper 25 m of the water column; a secondary peak occurs in late summer and early fall (Buchanon and Foy 1980).

Research conducted by MUN in Gilbert Bay since 1998 involved plankton sampling to capture cod eggs and larvae. Zooplankton samples were also collected and preserved. Zooplankton samples collected near the head of Gilbert Bay in August 1998, consisted primarily of calanoid copepod, and Cladoceran species. Cladocerans identified included *Evadne* sp., *Podon* sp. and others that resembled small-bodied Bosminidae (Robin Anderson DFO, Northwest Atlantic Fisheries Centre, P. O. Box 5667, St. John's NF A1C 5X1, pers. comm.). Samples containing Bosmina were collected near the surface (<3 m depth in fresh water). These species likely originated from the Gilbert River or Shinneys River. Samples have not been thoroughly examined to characterize species diversity or composition.

Ichthyoplankton samples collected from Gilbert Bay (1998-2000), between May and August, consisted of a small number of fish species. Those species collected from plankton samples were consistent with adult fish species captured in Gilbert Bay (Morris 2000) and included: Atlantic cod (*Gadus morhua*), sculpin (*Myocephalus* sp.), radiated shanny (*Ulvaria subbifurcata*), American plaice (*Hippoglossoides platessoides*), and gunnels (*Pholis* spp.). These samples were collected from The Shinneys, a semi-isolated portion of Gilbert Bay (fig 2.). High densities of Atlantic cod eggs were collected at the same location in Gilbert Bay, when adult Atlantic cod were observed to be in spawning condition.

The primary production cycle that occurs in Gilbert Bay probably plays an important role in the survival of larval cod. Larval cod feed upon zooplankton. The feeding environment into which larval cod hatch is known to influence their survival and affect year class strength (Helle and Pennington 1997; Ellertsen et al . 1980; Cushing 1990; Leggett and DeBlois 1994). However, measuring the interactions of prey, predators, and environmental conditions upon survival of Atlantic cod larvae and pelagic juveniles has challenged fisheries scientists for many years (Anderson 1988; Cushing and Horwood1994; Heibig et al 1992). Studies are complicated by the difficulty to effectively sample large and dynamic systems, such as the Northwest Atlantic Ocean or open coastal bays. The relatively small scale and isolated nature of Gilbert Bay, however, may facilitate suitable measurements needed to compare the interrelationships of variables affecting survival and recruitment of Atlantic cod larvae. We suggest a quantitative monitoring program to measure physical and biological variables (e.g. temperature, salinity, turbidity, circulation patterns, nutrients and plankton) in Gilbert Bay to better understand its ecosystem processes. A similar monitoring program has been suggested for the Musquash Estuary AOI (Singh *et al.* 2000).

BENTHOS

Few studies have looked at benthic ecosystems along coastal areas of Labrador. Barrie (1979) looked at soft sediment communities along the Labrador coast, north of Cartwright. Fletcher *et al.* (1975) have described some of the species present in bays along the south Labrador coast, but their assessment focused primarily on the abundance of commercial species. More recently, Memorial University and DFO have conducted a preliminary analysis of the benthic community in Gilbert Bay.

Barrie (1979) described the diversity of infaunal communities within differing sediments from coastal Labrador. Polychaetes made up the largest percent of both numbers and species. Amphipods, pelecypods and gastropods made up the remaining infauna. The average density of benthic organisms from Labrador samples was 1028 per square meter, but varied with sediment size (Barrie 1979). The largest number of individuals was found in very fine sediments (.063-.12 mm diameter), with less in sand substrates (1-2 mm diameter). Barrie (1979) depicts two benthic communities along the Labrador coast, the first associated with exposed coastal areas and the second was found in more protected bays and with a high diversity of grain size. Species diversity was greatest at medium exposures where both the environmental heterogeneity and substrates diversity was also greatest (Barrie 1979). Protected environments were characterized by *Prionospio steenstrupi*, *Protomedia grandimana* and *Nepthys*, which are the best indicators of sheltered environments (Barrie 1979).

A scuba diving study conducted in Gilbert Bay by Fletcher *et al.* (1975) assessed resource potential of Gilbert Bay and other bays along the Labrador coast. This study was restricted to a depth of 16 m and focused on shellfish having potential commercial importance. They reported a moderate abundance of clams (*Mya* spp., and *Macoma balthica*), cockles (*Clinocardium ciliatum* and *Serripes groenlandicus*), mussels (*Mytilus edulis*) and Iceland scallops (*Chlanys islandicus*). A low abundance of northern whelk (*Buccinum undatum*) and duck foot whelk (*Aporrhais occidentalis*) were reported. Gilbert Bay was reported to have a low density of sea urchin (*Strongylocentrotus droebachiensis*) compared to other bays and only 30% exceeded 4 cm in diameter.

During 1998 and 1999, Memorial University and DFO conducted a preliminary survey of the benthic community within Gilbert Bay which focused on the description of habitat and predominant epibenthic fauna. A dredge was used to collect samples and an underwater video camera was used to observe habitat. In general, soft sediments were found at depths >12m and these sediments contained an infaunal community of clams, polychaetes and oligochaetes. At many locations there was an abundance of coralline algae. Many invertebrate species (Table 1) were found living within the crevices in the coralline algae. Many of these species were identified as important food items of Gilbert Bay cod (Morris 2000).

Iceland scallops are abundant at many locations in Gilbert Bay. A commercial scallop fishery developed in this area primarily since the northern cod-fishing moratorium in 1992. Dredges used to capture scallop scrape over the bottom leaving marks that are easily identified on soft bottom substrates. Benthic organisms are sensitive to the effects of scallop dredging (Dayton *et al.* 1995), particularly the encrusting and sedentary species. It is therefore important to consider the effect of scallop dredging upon habitat and species diversity in Gilbert Bay. The limited amount of video information available does not allow a complete assessment of habitat alteration due to scallop dredging in Gilbert Bay. Future work may provide a better understanding of the effects of fishing gear on benthic habitats within Gilbert Bay. Areas affected and unaffected by scallop dredging within Gilbert Bay may provide a suitable experimental situation to compare the effect of scallop dredging on benthic habitats within Gilbert Bay.

Some of the most biologically productive areas in Gilbert Bay surround the narrow passages connecting various arms of Gilbert Bay, such as the River Out area (Fig. 6). These passages are less than 50 m wide and 10 m in depth. The substrate consists of varying sizes of boulder, cobble and gravel, and the areas are subjected to strong tidal flows during the rising and falling tides. The strong current in this area may supply ample food to filter and deposit feeders of both the epifauna and infauna, as well as replenish oxygen and remove unwanted metabolites (Barrie 1979). Loons, black ducks, mergansers, a variety of shore birds, and black bears were observed to frequent these locations. Dense mussel beds line the shores at these locations. At higher water depths (5 – 10 m) high densities of sea urchins were observed. Iceland scallop were abundant at these locations but are known to be common in other parts of the bay also.

A diversity of habitat types were identified at differing locations in Gilbert Bay with extreme variations in the density of epibenthic fauna. Substrate types occurring in Gilbert Bay range from bedrock outcrops to silt. The variation in grain size will influence the distribution of infaunal communities (Barrie 1979) and the diversity of benthic organisms that reside in Gilbert Bay. The bay is well protected from wave action, having low exposure, which Barrie (1979) suggests could reduce the diversity of organisms as compared to areas with medium exposures. Strong tides and estuarine conditions create a range of differing environmental conditions and support a wide diversity of habitats.

MARINE FISH

A relatively small number of fish species have been observed within Gilbert Bay. Observations include Atlantic cod, rock cod (*Gadus ogac*), alligator fish (*Aspidophoroides sp*), gunnels (*Pholis sp*), radiated shanney (*Ulvaria subbifurcata*), sculpin (*Myoxocephalus scorpinus and Gymnocanthus tricuspis)*, American plaice (*Hyppoglossoides platessoides*), threespine stickleback (*Gasterosteus aculeatus*), Atlantic salmon (*Salmo salar*), Arctic charr (*Salvelinus alpinus*), brook charr (*S. fontinalis*) and

lumpfish (*Cyclopterus lumpus*). Area residents report that capelin and herring occupy this area as well.

Research conducted by MUN scientists in Gilbert Bay since 1996, has focused on Atlantic cod. Researchers have identified several biological characteristics that set Gilbert Bay cod apart from other Atlantic cod. Differences involve genetics (Ruzzantee *et al.* 2000) movement patterns (Green and Wroblewski 2000), growth rates, timing of spawning, spawning locations, and primary feeding habits (Morris and Green submitted). Still lacking, however, is an accurate estimate of cod abundance in Gilbert Bay. A mark recapture study has been ongoing since 1997, however, a population estimate based on tag returns is complicated by the observed movement patterns of the population and the commercial fishery in Gilbert Bay. Migratory northern cod from offshore areas move into Gilbert Bay during summer and mix with the inshore cod in Gilbert Bay. These fish are distinguished on the basis of colouration. Offshore cod are silvery-gray, whereas Gilbert Bay cod are much darker and often reddish to golden brown (Fig. 7). It has not been determined if offshore cod are able to adjust their colouration to match that of resident Gilbert Bay cod during their lives. Researchers at MUN are conducting a series of experiments to investigate factors affecting the colouration of Atlantic cod, in Gilbert Bay.

MARINE MAMMALS

Many marine mammal species are common along the Labrador coast. Seal species that occur in the Gilbert Bay area include the ringed seal (*Phoca hispida*) an arctic species, harbour (*P. vitulina*) and gray seals (*Halichoerus grypus*) two temperate species, and the hooded (*Cystophora cristata*) and harp seal (*P. groenlandica*) migratory species which move between temperate and Arctic waters (Anon 1986). Whales, dolphins and porpoises known to occur in the Gilbert Bay area include: fin (*Balaenoptera physalus*), sei (*B. borealis*), humpback (*M. novaeangliae*), minke (*B. acutorostrata*), killer (*Orcinus orca*), and pothead (*Globicephala melaena*) whales; white beaked (*Lagenorhynchus albirostris*), and Atlantic white-sided (*L. acutus*) dolphin; and harbour porpoise (*Phocoena phocoena*) (Leatherwood *et al.* 1976). Whales are not as common in Gilbert Bay, perhaps because of the restrictive nature of the bay entrances. However, seals are common and have been sighted during many field visits.

Harp seals whelp in large herds on ice flows off southern Labrador and northern Newfoundland. Adults migrate north in spring around May, followed by the young seals born several weeks earlier. Harp seals spend the summer in the eastern Canadian Arctic and around Greenland and migrate back to whelping areas off southern Labrador by late December (Annon. 1986). Although many seals remain offshore, some pass along Gilbert Bay during their northern and southern migrations. The northwest Atlantic harp seal population reached its lowest abundance during the early 1970's. However, it has increased substantially since then (Healey and Stenson 2000). From the early 1970's until 1996, this seal population increased to more than 5 million animals, the highest level since the time series was initiated. It has remained stable in recent years (Healey and

Stenson 2000). Interviews conducted with residents of Port Hope Simpson and Williams Harbour have indicated that in recent years harp seals show up earlier in spring, return earlier in fall and stay around for longer periods of time than they have in the past. Residents also reported an increase in the number of seals. Two explanations for this observation are that the seal herd is getting larger or changes have occurred in the distribution pattern of seals, due to changes in environmental conditions (Gary Stenson DFO, Northwest Atlantic Fisheries Centre, P. O. Box 5667, St. John's NF A1C 5X1, pers. comm).

BIRDS

There are 146 bird species expected to occur regularly in Labrador (Meades 1990). The bulk of Labrador birds are summer residents, overwintering further south and migrating northward in spring to breed (Todd 1963). Several species of shorebirds, seabirds, waterfowl, and raptors were observed in association with the marine environment in the Gilbert Bay area, none of which are permanent residents. There has been little published information describing the activities of various bird species within Gilbert Bay, such as breeding and feeding areas.

Seven shorebird species were identified by Jacques Whitford Environmental Limited (JWEL) (1997) near Voisey Bay, Labrador including: American golden plover (*Pluvialis dominica*), semipalmated plover (*Charadrius semipalmatus*), hudsonian godwit (*Limosa haemastica*), semipalmated sandpiper (*Calidris pusilla*), least sandpiper (*C. minutilla*), white-rumped sandpiper (*C. fuscicollis*), and pectoral sandpiper (*C. melanotus*). These bird species pass along Gilbert Bay during their north and south migrations. The most common shorebirds observed in Gilbert Bay were sandpipers. Shorebirds in Gilbert Bay were most frequently observed near the shallow entrances to several arms of Gilbert Bay. These locations are possibly good feeding areas.

Several seabird species occur along the Labrador coast; however, we observed seabirds less frequently in Gilbert Bay than along the open coast. Seabirds observed near Gilbert Bay include the great black backed gull (*Larus marinus*), herring gull (*L. argentatus*), black legged kittiwake (*Rissa tridactyla*), and terns (*Sterna* spp.). At 52°N latitude along the Labrador coast, gulls comprise the majority of the breeding birds (Lock 1979). Each year from 1997 to 2000, during July and August, we observed many terns (100-200) at a small island (Fig. 6) near one of our study areas in Gilbert Bay. On the island several birds appeared to be nesting. Terns appeared to defend the island as we approached, by making loud vocalizations and swooping towards us.

Five species of *Alcidae* were observed in the area surrounding Gilbert Bay, including razorbills (*Alca torda*), murres (*Uria spp*), black guillmots (*Cepphus grylle*), and Atlantic puffins (*Fratercula arctica*). These species are common along the Labrador coast (Nettleship and Birkhead 1985; Lock 1979). Alcids generally breed at locations north of Gilbert Bay (Lock 1979).

During several weeks of field work in Gilbert Bay each year since 1998, few raptor species were observed. Ospreys (*Pandion haliaetus*) were commonly observed near the estuary of the Shinneys River, and Bald eagles (*Haliaetus leucocephalus*) were observed near Gilbert Bay.

Species of waterfowl observed in or near Gilbert Bay during our field studies have included common eiders (*Somateria mollissima*), scoters (*Melanitta* spp.), Canada geese (*Branta canadensis*), black ducks (*Anas rubripes*), mergansers (*Mergus serrator*), and common loons (*Gavia immer*). These waterfowl were observed in Gilbert Bay in the River Out area and at a small salt marsh located in The Shinneys. The salt marsh (Fig. 6) covers an estimated 500 m^2, within which various species of birds were observed. This area appeared to attract a number of bird species, as well as bird hunters. Several blinds were established in the area and the presence of expended shotgun cartridges suggests that it is a good hunting location.

HUMAN INFLUENCE

We are not aware of any sources of pollution in Gilbert Bay and therefore have not reported on any issues related to water quality, nutrients, or contaminants in this document. There are no permanent residents living within Gilbert Bay, and buildings are limited to seven small cabins at different locations within the bay. The major anthropogenic affects in Gilbert Bay are due to fishing and fishing gear used in this area.

People along the southern Labrador coast, most of whom are Labrador Mêtis, harvest several species of plants and animals for subsistence and commercial purposes. Primary interest in Gilbert Bay relates to commercial and recreational fishing. Presently, commercially fished species include Atlantic cod and Iceland scallop, and to a limited extent, snow crab and whelk. In the past, salmonids comprised an important component of the commercial net fishery. Today, Atlantic salmon, Arctic charr, and brook charr are fished for sport and subsistence. Other marine species harvested in the Gilbert Bay area for recreational or subsistence purposes include, Atlantic cod, eider ducks, scoters, geese, mergansers, murrs, crab, mussels, whelk, scallop, and seals. Aboriginal peoples have hunted seals and whales for subsistence purposes along the Labrador coast since prehistoric times. Seals have been fished commercially in this area at least since the early eighteenth century (DFO 2000). Whales were fished by Basque whalers in the Newfoundland Region as early as 1578 (Slijper 1962).

The first written account of cod in Gilbert Bay was made by Ben Powell (Powell 1987). Local elders living in the general area recall fishing Gilbert Bay cod for food as early as 1969 (Morris *et al.* In Prep.). Gilbert Bay cod were fished commercially by a family enterprise from 1973 until the northern cod fishery moratorium in 1992. This family was initially attracted to Gilbert Bay because of the abundance of salmonids, rather than Atlantic cod. Gilbert Bay continues to support a recreational and food fishery for salmonids. There is a limited (individual quota) commercial northern cod fishery in the Gilbert Bay area. However, approximately 70% of the bay has been restricted from

cod fishing by DFO since 1998 (Fig. 8). Gilbert Bay is managed as part of NAFO Division 2J.

Upon reopening of the northern cod fishery in 1998, several fish harvesters (10-15) fished cod commercially in Gilbert Bay. At this time northern cod was virtually absent on traditional fishing grounds along the coast. In 1998, the relative abundance of cod in Gilbert Bay enabled fish harvesters to catch individual quotas from within Gilbert Bay. After 1998, local residents became concerned over a possible decrease in the abundance of cod in Gilbert Bay (Morris *et al.* In Prep) and DFO restricted fishing from 70 % of the bay. In the absence of information needed to conduct a population estimate and in light of local knowledge, the Gilbert Bay cod population should be managed with extreme caution to prevent significant depletion.

Iceland scallop is currently fished commercially throughout the majority of Gilbert Bay (Morris *et al.* In Prep.). The commercial scallop fishery in Gilbert Bay is relatively new, it developed since the northern cod fishery closed. Between 1992 and 2000 there have been several changes in this fishery and today fewer people rely on the scallop fishery in Gilbert Bay than during the early-mid 1990's. Many people have entered other fisheries such as snow crab and northern shrimp (Morris *et al.* In Prep.).

FUTURE CONSIDERATIONS

During this investigation we have identified several information gaps regarding the Gilbert Bay ecosystem. These information gaps need to be prioritized, such that important questions relating to the proposed MPA are addressed. Additional research is needed to better understand the population of Atlantic cod. Determining an estimate of population size and developing a monitoring program will be important for future management of Gilbert Bay cod. Understanding mechanisms that isolate this population is also important. The retention of cod eggs within Gilbert Bay may contribute to the uniqueness of the population. Understanding the benthic habitat and habitat alterations, due to scallop fishing, is important from a conservation and protection perspective, as well as for the benefit of evaluating the site as a potential MPA.

The dynamic nature of pelagic systems and the prevalence of variability over large scales blur the linkages between physical and biological processes (Steele 1975). Therefore, it is somewhat difficult to describe relationships needed to accurately predict population abundance from year to year. In many cases there is little empirical evidence that defines a relationship between spawning stock biomass and recruitment although an intrinsic relationship exists. Generally, there is too much unaccountable variation over a large spatial scale to accurately predict how variables affect population abundance from one year to the next. However, in a small geographically fixed area such as Gilbert Bay the circumstances may exist to do exactly that; predict biomass from ecosystem processes.

Gilbert Bay exhibits many of the requirements to become a MPA, as outlined in the *Oceans Act*. However, we identified several information gaps relating to both physical and biological ecosystem processes;

- Annual water circulation and stratification patterns in Gilbert Bay.
- Detailed time series of physical data, such as water temperatures, salinity, chlorophyll a, turbidity etc. to complement future scientific studies.
- The current abundance of cod presently in Gilbert Bay and the potential carrying capacity.
- Movement patterns of Atlantic cod within Gilbert Bay and between the ocean and Alexis Bay.
- Plankton and zooplankton composition and annual changes.
- Detailed characterization of benthic species and habitats.
- Effects of scallop dredging on benthic habitat.

It will be important to identify and prioritize the important information gaps that relate to the MPA program, we have not attempted to do so here. Ecosystem health and detection of environmental changes are suggested by Singh *et al.* (2000) as examples of important criteria that may guide future management decisions for MPA sites. Various stakeholders will be responsible for the evaluation of Gilbert Bay as a MPA and for future planning and management decisions.

ACKNOWLEDGEMENTS

Dr. John Green and George Rowe contributed to many of the field observations in this report. Commercial fish harvesters from the Gilbert Bay area provided information pertaining to resource use and commercial fishing activities. We thank Tony Bowdring and Kirk Regular for their assistance in preparing maps. Dr. Robin Anderson assisted in the identification of zooplankton. Helen Griffiths, Charlene Coats, Natasha Antle, Robert Gregory and Maria Buzeta provided helpful suggestions of the manuscript.

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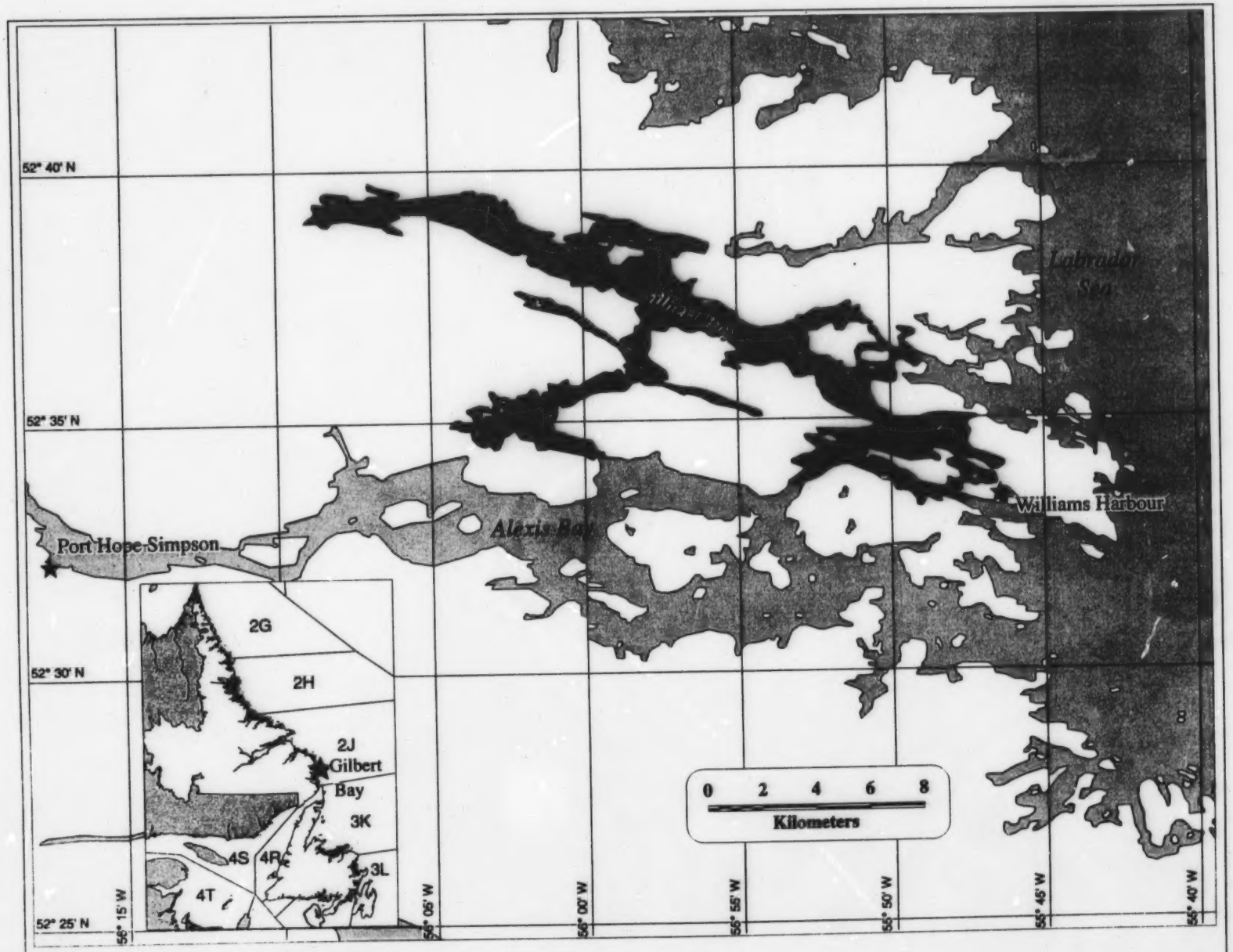

Figure 1. Location map of Gilbert Bay.

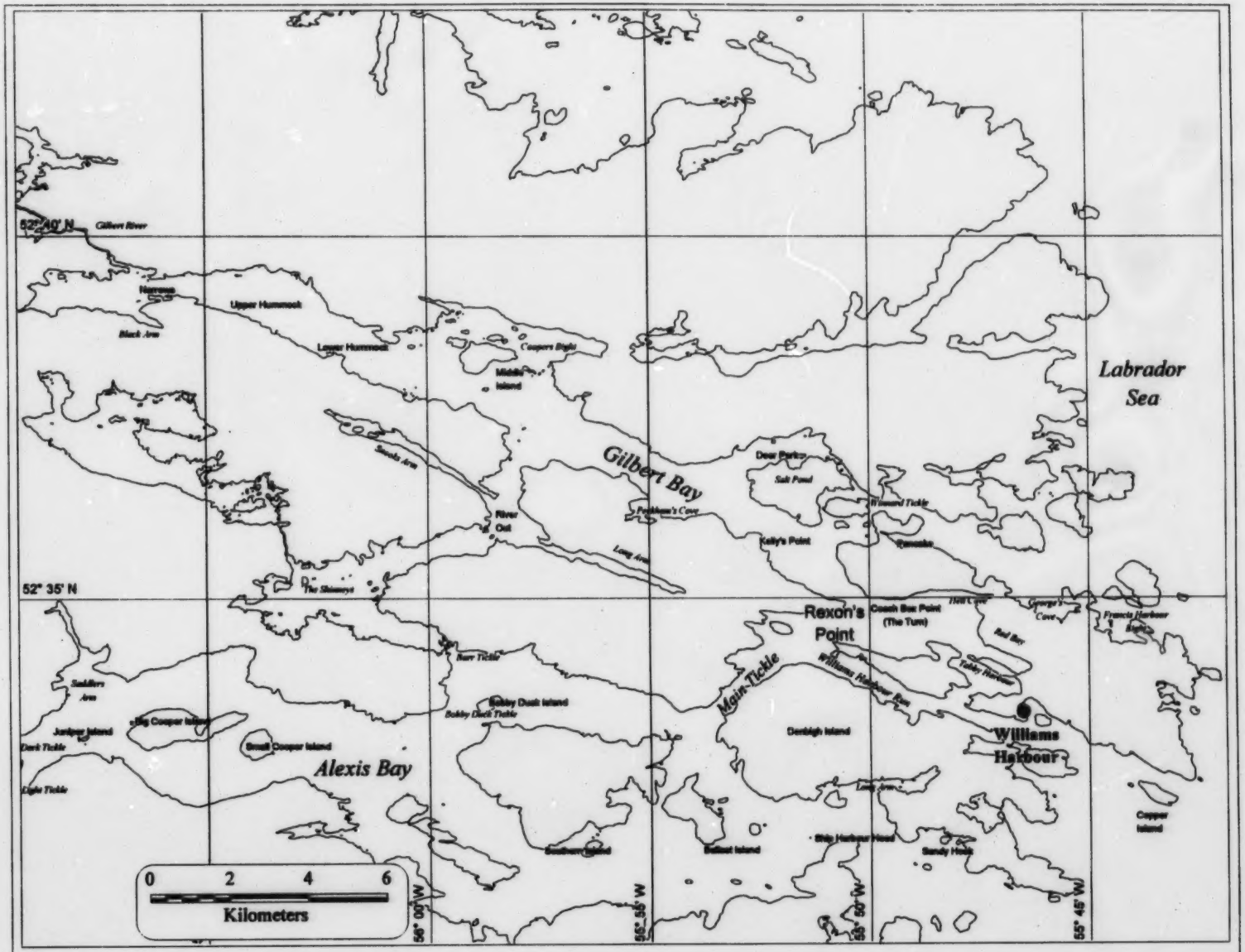

Figure 2. Local place names in Gilbert Bay.

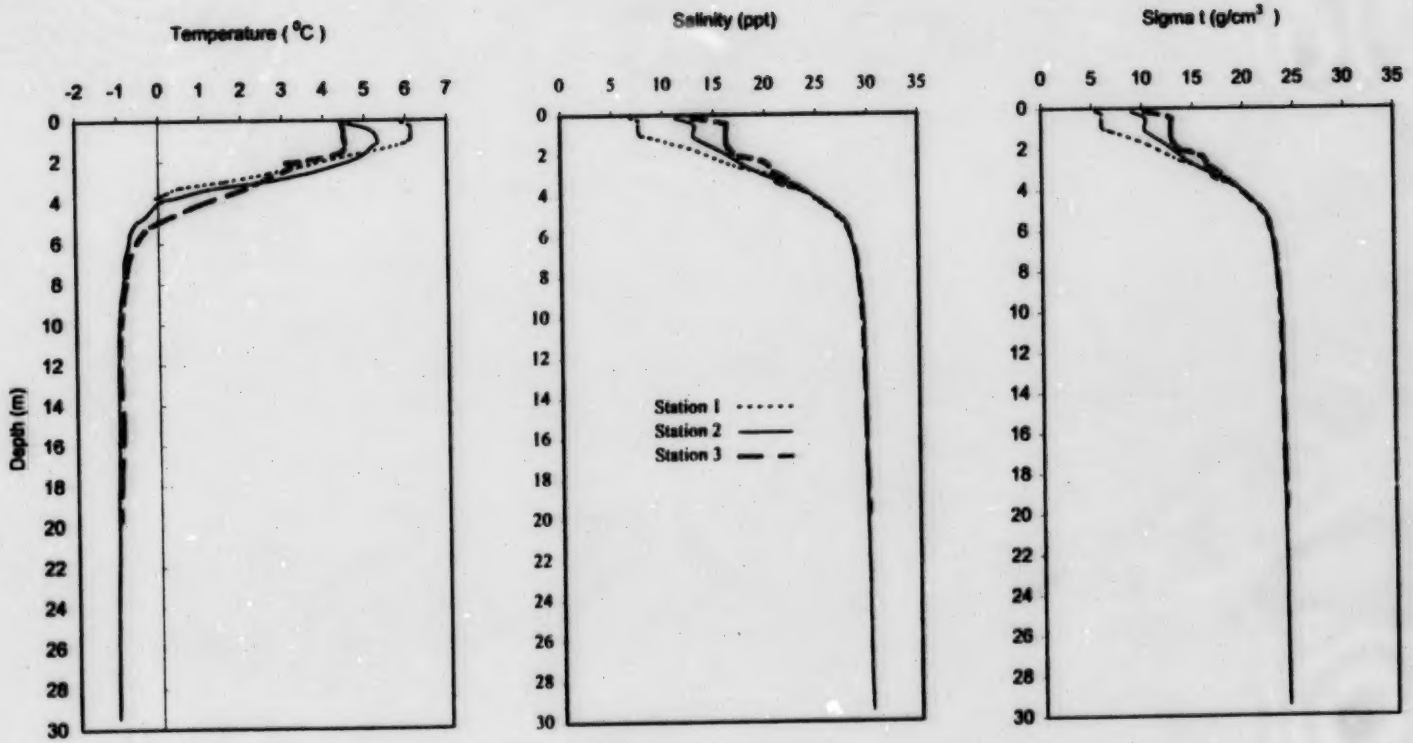

Figure 3. Vertical profiles of water temperature, salinity, and density (sigma-t) at four locations in The Shinneys June 1, 1997. Profiles were taken at increasing distance from the mouth of the Shinneys River. Stations 1-3 were located at approximately1, 2, and 4 km respectively from the river mouth.

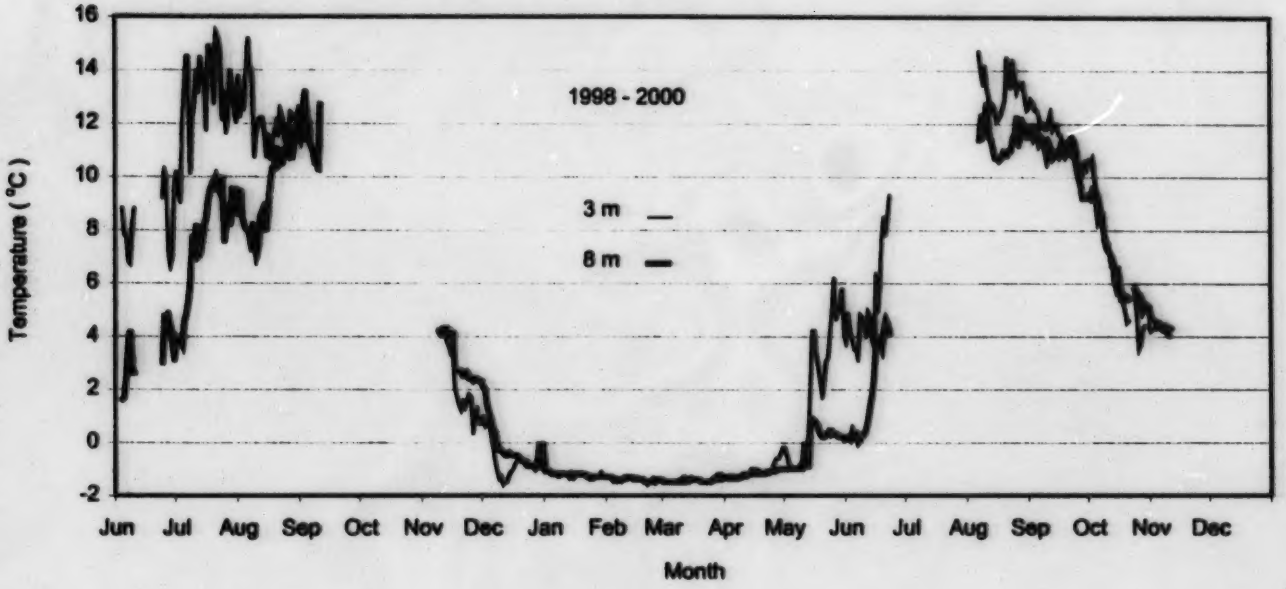

Figure 4. Daily water temperature recorded in Gilbert Bay from May 1998 until December 1999.

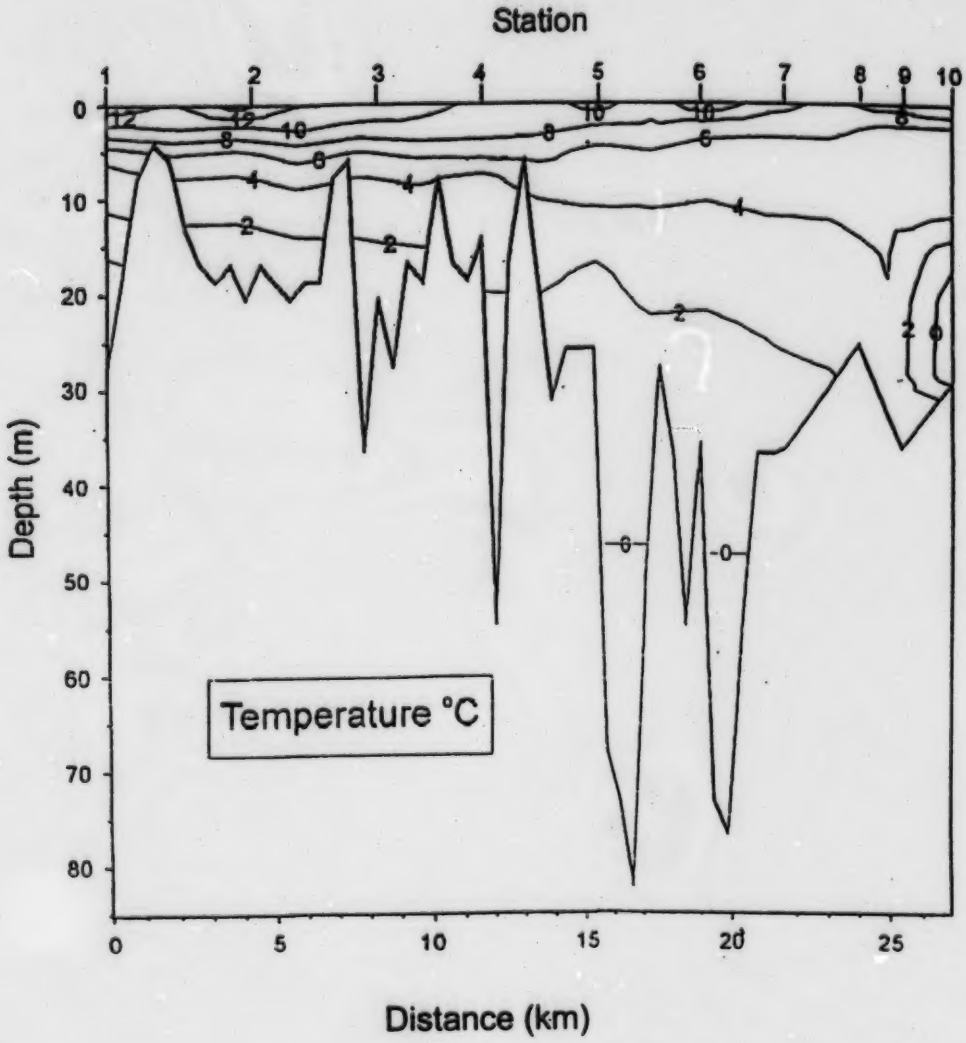

Figure 5. Temperature and depth profile of Gilbert Bay. On the x-axis 0 km represents the head of Gilbert Bay and 27 km represents the mouth of Gilbert Bay (Adapted from Green and Wroblewski 2000).

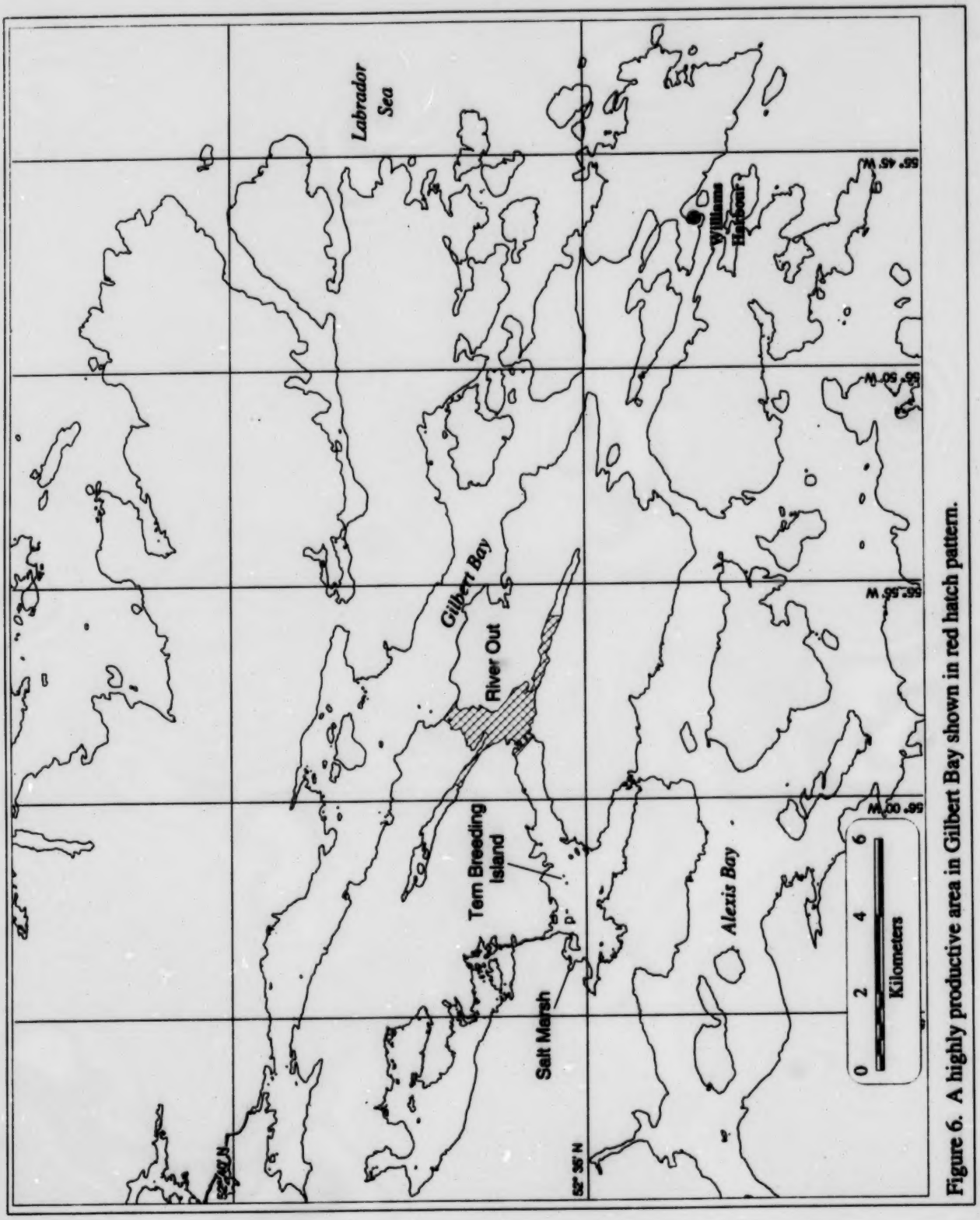

Figure 6. A highly productive area in Gilbert Bay shown in red hatch pattern.

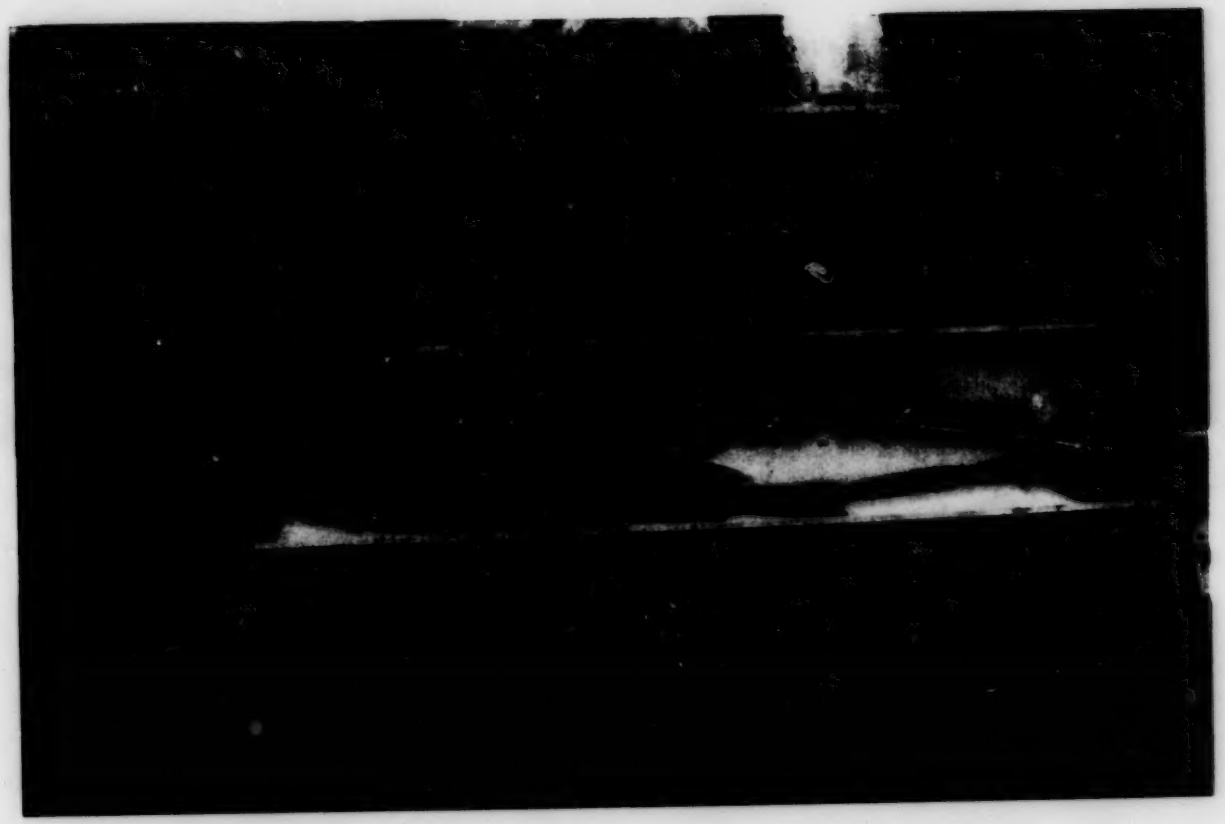

Figure 7. Resident Atlantic cod from Gilbert Bay (left) and an offshore northern cod (right). Characteristics recognized by local people since the early 1970's.

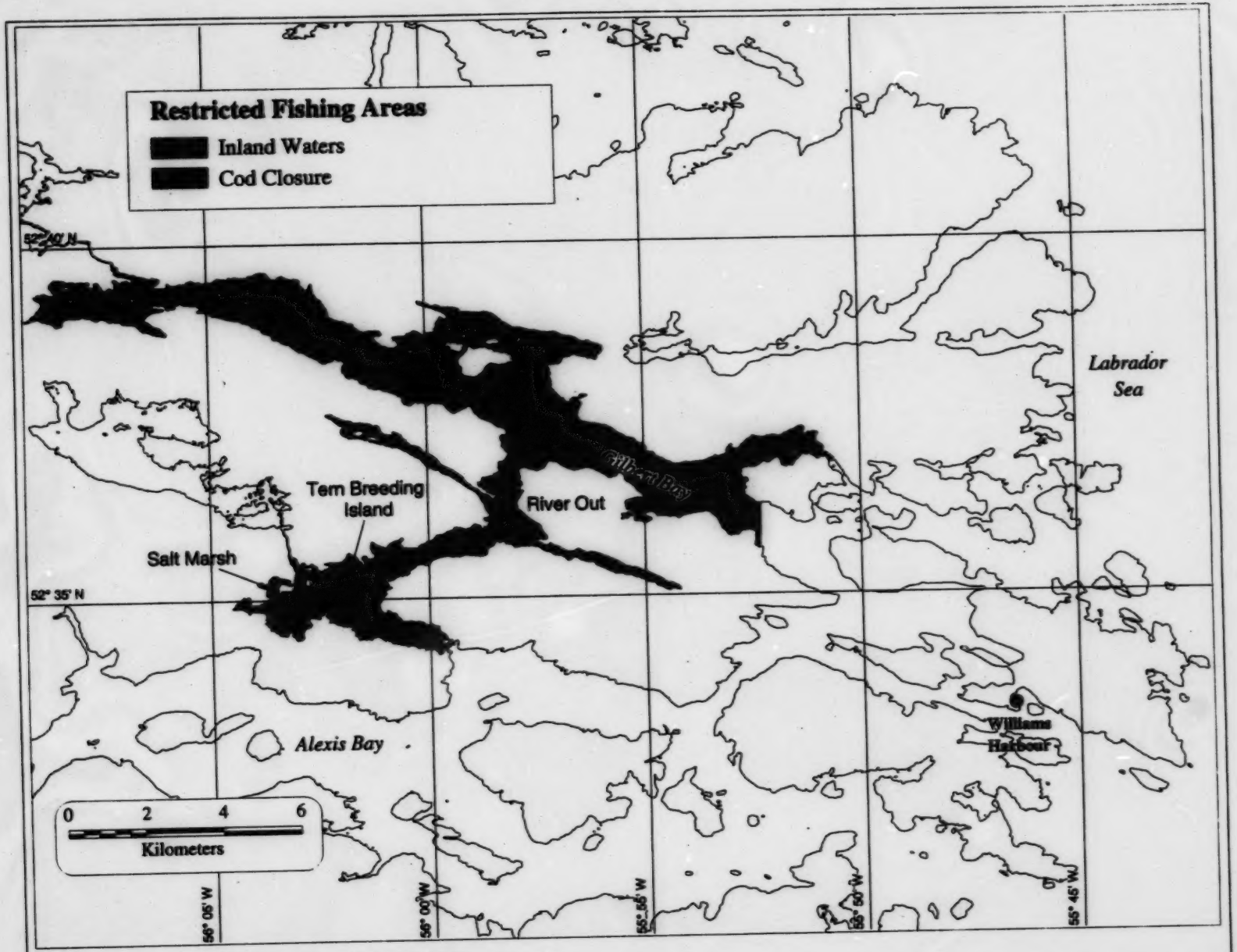

Figure 8. Restricted fishing areas in Gilbert Bay.